BEFORE THE NORTHLAND REGIONAL COUNCIL HEARINGS PANEL

UNDER	the Resource Management Act 1991
IN THE MATTER OF	Proposed Northland Regional Plan – GE / GMO provisions

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STATEMENT OF PRIMARY EVIDENCE OF JACK ALFRED HEINEMANN
ON BEHALF OF THE WHANGAREI DISTRICT COUNCIL AND FAR NORTH DISTRICT COUNCIL

12 October 2018

Contents

Introduction

1. My full name is Jack Alfred Heinemann. I reside in Christchurch. I am a Professor in the School of Biological Sciences of the University of Canterbury, specialising in the field of molecular genetics.

2. I have a doctorate in Biology/Molecular Biology from the University of Oregon. I have a double BSc (with honours) in Biochemistry and Molecular Biology from the University of Wisconsin-Madison.

3. I am the Director of the Centre for Integrated Research in Biosafety, University of Canterbury. I have previously held academic posts at GenØk-Centre for Biosafety in Norway, and the National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratories, in the United States. I have also been an adjunct professor at the University of Montana and a guest scholar at the Rockefeller University in New York.

4. From 2009 to 2016, I served the United Nations Convention on Biological Diversity Secretariat on the Ad Hoc Technical Expert Group (AHTEG) on Risk Assessment and Risk Management. In 2014 I was part of a winning bid for an internationally contested contract to design and teach a risk assessment training course to the government of Swaziland. I have provided expert advice on horizontal gene transfer to the New Zealand Environmental Risk Management Authority. I have previously held other roles in other multinational scientific bodies, such as the author representative to the intergovernmental panel of the International Assessment of Agricultural Knowledge, Science and Technology for Development.

5. I have also advised both multinational scientific bodies, such as the United Nations Food and Agriculture Organisation, national bodies, such as the Swiss National Academies of Science[1], and professional organisations such as the American Academy of Microbiology. I was chosen by the Commerce Commission to provide advice on the marketing claim "GM free" as applied to chickens fed GM plant material.[2] I was chosen after the Commission did due diligence to ensure independence of the expert advice it sought.

6. I have 133 published articles in my profession, with 71 peer-reviewed. I have spoken at over 40 international conferences, and have been a keynote speaker on 10 occasions.

7. I have served the High Court of New Zealand as an expert witness. I have served as an expert witness for Auckland City Council as well as Whangarei and Far North District Councils.

8. I provided this statement of evidence as my expert opinion under a contract to the University of Canterbury, but it is not presented as an

[1] I am currently a member of the Academies' Expert Working Group developing policy-relevant documents on genetic engineering.

[2] http://www.comcom.govt.nz/the-commission/media-centre/media-releases/detail/2009/inghamswarnedovergmfreechickenclai. Access date 30 March 2018.

opinion of the University of Canterbury.

Code of Conduct

9. I confirm that I have read the Code of Conduct for Expert Witness contained in the Environment Court Practice Note and that I agree to comply with it. I confirm that I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person.

Scope of Evidence

10. I have been asked by Whangarei and Far North District Councils to review the relevant literature and research to evaluate whether there is scientific uncertainty regarding the use and safety of GMOs, with particular attention to the coastal marine area, and whether GMOs discharged into the coastal marine environment could adversely affect the environment and/or result in significant costs.

11. I have also been asked to assess whether there is a science-based case for including in the proposed Regional Plan for Northland provisions to address the uncertainty (including lack of scientific consensus) and/or lack of information about the risks and benefits from outdoor use of GMOs, including long-term (potentially irreversible) environmental effects.

12. Among the considered options in the Whangarei and Far North District Council section 32 analysis dated 23 March 2018, the preferred option 2 objectives F.0.2.1 and F.0.2.2 are based upon a precautionary approach to risk management, an adaptive approach that requires decision-makers to exercise caution, including the prohibition or postponement of an activity, when faced with uncertainty and/or insufficient reassurance that the activity will not result in harm to members of the public or the environment. I will address these matters under the following headings: risk assessment and the precautionary approach and uncertainty and lack of scientific agreement.

13. In my statement I will refer to the products of genetic modification as GMOs (or sometimes LMOs); these are the products of the process of genetic engineering. However, I quote from sources that occasionally use similar but not identical terms such as rDNA, LMOs and GEOs. rDNA is 'recombinant DNA'; LMOs are living genetically modified organisms; and a GEO is also a genetically engineered organism.

International Obligations in the Context of GMOs; Precautionary Approach

14. The Rio Declaration on Environment and Development[3] arose from the Rio "Earth Summit". It is a set of principles defining a state's responsibilities and rights. Principle 15 of the Declaration[4] establishes the right of a

[3] http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm.

[4] Principle 15 of the Rio Declaration on Environment and Development: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their

country to take precautionary action to prevent environmental degradation in cases where there are threats, but no conclusive evidence, of serious or irreversible damage.

15. The Convention on Biological Diversity (CBD) is an international treaty that was inspired by the global community's growing commitment to sustainable development as expressed through the Rio "Earth Summit".[5] It entered into force in 1993 and as of March 2018 it has 196 parties bound by its obligations. In the preamble of the Convention it is noted that: "Where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat."[6]

16. Second among its three primary objectives is the "sustainable use of the components of biological diversity."[7] In other words, the Convention does not seek to create museums of biological diversity, but ensure that the environment and agriculture is managed by sound ecological principles and economically sustainable communities that preserve biological diversity through its use.

17. The Cartagena Protocol[8] to the Convention on Biological Diversity is an international biosafety agreement on the movement of products of modern biotechnology, including living modified organisms, across country borders. It entered into force on September 2003 and has 171 parties as of March 2018. The precautionary approach to risk assessment is described in Article 1. "In accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development, the objective of this Protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary [across borders] movements."

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capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

[5] https://www.cbd.int/history/.

[6] Additionally, Decision II/10 on conservation and sustainable use of marine and coastal biological diversity, adopted by the Conference of the Parties at its second meeting in Jakarta in November 1995, states that: "The work [of the Secretariat on marine and coastal biological diversity] should not be impeded by the lack of full scientific information and will incorporate explicitly the precautionary approach in addressing conservation and sustainable use issues." Furthermore, Article 8(g), together with article 19.3 and 19.4, of the CBD implies that Parties should establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from biotechnology that are likely to have adverse effects on the conservation and sustainable use of biological diversity, taking also into account the risks to human health.

[7] https://www.cbd.int/intro/default.shtml. Article 10e says: "Encourage cooperation between its governmental authorities and its private sector in developing methods for sustainable use of biological resources." https://www.cbd.int/convention/articles/default.shtml?a=cbd-10.

[8] http://bch.cbd.int/protocol.

18. Additionally, in both Article 10.6 and 11.8 of the Protocol it states that: "Lack of scientific certainty due to insufficient relevant scientific information and knowledge regarding the extent of the potential adverse effects of a living modified organism on the conservation and sustainable use of biological diversity in the Party of import, taking also into account risks to human health, shall not prevent that Party from taking a decision, as appropriate, with regard to the import of the living modified organism in question..."

The Risk Assessment Framework for GMOs

19. In this part of my statement of evidence I will set out general arguments about scientific risk assessment and risk management of genetically modified organisms (GMOs) and the difference between risk assessment and decision-making.

20. The risk assessment framework that I am most familiar with is precautionary, comparative and case-by-case. This is the prevailing international framework as well.[9] A useful description of this framework is provided in guidance developed to assist users of the aforementioned Cartagena Protocol on Biosafety.[10]

21. A risk assessment informs decision-making but decisions can be based on more than a risk assessment. According to the official guidance on the Protocol: "It is important to note that risk assessor(s) are requested to recommend whether the risks are 'acceptable' or not. However, the definition of 'acceptability' may not be part of a risk assessment but could be pre-established, for example, in thresholds included in government policies or in the mandate given to the risk assessor. *Likewise, the final decision on whether to approve (with or without conditions) or prohibit the specific use of the LMO is taken during the decision-making process, which may take into account, depending of the national regulatory framework and among other things, government policies, public opinion, anticipated benefits, costs of the risk management measures and socio-economic considerations*" [emphasis added].[11]

22. The purpose of case-by-case *risk* assessment is to ensure that all potential adverse effects that might be caused by a GMO are identified, characterised, eliminated, minimised or mitigated. Neither the Protocol nor a comparative risk assessment were designed to identify, verify or compare proposed *benefits* of a GMO. That is appropriate but can leave

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[9] **Gee, D.** 2013. More or less precaution? In Late lessons from early warnings: science, precaution, innovation, D. Gee, P. Grandjean, S. Foss Hansen, S. van den Hove, M. MacGarvin, J. Martin, G. Nielsen, D. Quist, and D. Stanners, eds. (Luxembourg: European Environment Agency), pp. 643-669.

[10] **CBD**. Training Manual on Risk Assessment of Living Modified Organisms in the context of the Cartagena Protocol on Biosafety. http://bch.cbd.int/cpb_art15/training.shtml. Access date, 19 April 2016.

[11] http://bch.cbd.int/cpb_art15/training/module3.shtml#Recommendationsastowhetherornottherisksareacceptableormanageable.

some to feel that benefits are understated. However, they are not. Benefits (supported by a proper benefit analysis and evidence) can be taken into consideration during decision-making.

23. In environmental risk assessment, case-by-case usually refers to either (or both) the GMO being evaluated and the likely potential receiving environment. [12] Therefore, each GMO may be assessed in every environment that it may be used in, rather than assume a risk assessment of the same GMO in a different environment would be sufficient. This is because the GMO may create different harms in different environments. For example, GM maize may have no wild relatives that could be affected by it in the US Midwest, but would have wild relatives in its centre of origin in Mexico. [13]

24. Moreover, not all GMOs need be plants. They can be GM animals, fungi, bacteria or viruses. Each type, as well as each modification, also describes a case. This is elaborated further below, beginning in paragraph 47, in the section on the Coastal Marine Area.

25. Peak scientific bodies, societies and international regulatory bodies (see e.g. paragraph 46) affirm the value for ongoing risk assessment of GMOs. The US National Academy of Sciences said: "There is an urgent need for publicly funded research on novel molecular approaches for testing future products of genetic engineering so that accurate testing methods will be available when the new products are ready for commercialization."[14]

26. New Zealand is not alone in regulating GMOs. There is substantial evidence of international agreement on the need to assess the risks of GMOs. The World Health Organisation estimates that internationally there are 15 legally binding instruments and non-binding codes of practice that address some aspect of GMO regulation or trade.[15] These are harmonised through domestic legislation of member countries. These member countries include New Zealand's trading partners.

27. Among the 15 legally binding instruments is the Cartagena Protocol on Biosafety, which I introduced in paragraph 17. It provides guidance for the purpose of assessing the risk of living GMOs (called products of modern biotechnology in Article 3 of the Protocol) released into the environment. Three of New Zealand's top 5 trading partners [16] belong to the Cartagena

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[12] A risk assessment done in accordance with the Cartagena Protocol might only consider the LMO released for intended use and therefore may not be sufficient when assessing the possible adverse effects that may arise if the LMO is to be used in different ways.

[13] **CONABIO**. 2017. Ecosystems and agro-biodiversity across small and large-scale maize production systems. In TEEB Agriculture & Food (Geneva: United Nations Environment Programme).

[14] **NASEM**. 2016. Genetically Engineered Crops: Experiences and Prospects (Washington, DC: The National Academies Press) .

[15] **WHO**. 2005. Modern food biotechnology, human health and development: an evidence-based study. (Geneva) Food Safety Department of the World Health Organization http://www.who.int/foodsafety/publications/biotech/biotech_en.pdf.

[16] **Immigration, N.Z.** Economic overview. https://www.newzealandnow.govt.nz/investing-in-nz/opportunities-outlook/economic-overview. Access date, 19 April 2016.

Protocol (European Union, China, and Japan). Moreover, New Zealand belongs to the Codex Alimentarius [17] - a joint body of the World Health Organisation and the United Nations Food and Agriculture Organisation – that issues science-based specialist risk assessment guidance on GM microorganisms, GM plants and GM animals (also called products of modern biotechnology in the Codex) for use in food. All of New Zealand's top 5 trading partners (including Australia and the United States) belong to Codex.

28. As the above paragraphs show, internationally, there is a consensus of the need for ongoing risk assessment of GMOs whether used as food or in the environment. The next issue that I wish to discuss is who should be involved in assessing the risk of GMOs.

29. As mentioned in paragraph 26, there is a substantial number of international agreements on the trade of GMOs and LMOs and products thereof. National legislation is aligned to these agreements. [14]

30. In some countries, regulation may devolve to sub-national levels. For example:

    a. Australia has a national food safety regulator that approves the use of GM-derived foods and an environmental regulator that approves the release of GMOs. In addition, the various states of Australia have legislation on the release of GMOs. Among the different states that have legislation, some have complete moratoria on GM plant cultivation, some exemptions for field trials, or prohibition of some types of GM plants. [18]

    b. In the European Union, member states are able to opt out of regulatory approvals for the release of GMOs and prohibit release in their territories. Sixteen member states have done so in respect of eight different GMOs, and another two have prohibited three GMOs. [19] Member states may also have sub-national regions that restrict or ban cultivation of GMOs (Figure 1).

31. Such actions by local governments are consistent with international biosafety agreements binding central governments. The Cartagena Protocol on Biosafety says in Article 2.4 that "[n]othing in this Protocol shall be interpreted as restricting the right of a Party to take action that is more protective of the conservation and sustainable use of biological diversity than that called for in this Protocol, provided that such action is consistent with the objective and the provisions of this Protocol and is in accordance with that Party's other obligations under international law."

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[17] http://www.fao.org/fao-who-codexalimentarius/en/.

[18] Food Standards Australia/New Zealand has responsibilty for food and the Office of the Gene Technology Regulator has responsibility for releases. **Tribe, D.** 2012. Gene technology regulation in Australia. A decade of a federal implementation of a statutory legal code in a context of constituent states taking divergent positions. GM Crops Food *3*, 21-29.

[19] As per Directive (EU) 2015/412. **USDA**. 2017. EU-28. GAIN Report USDA Foreign Agricultural Service SP1743 .

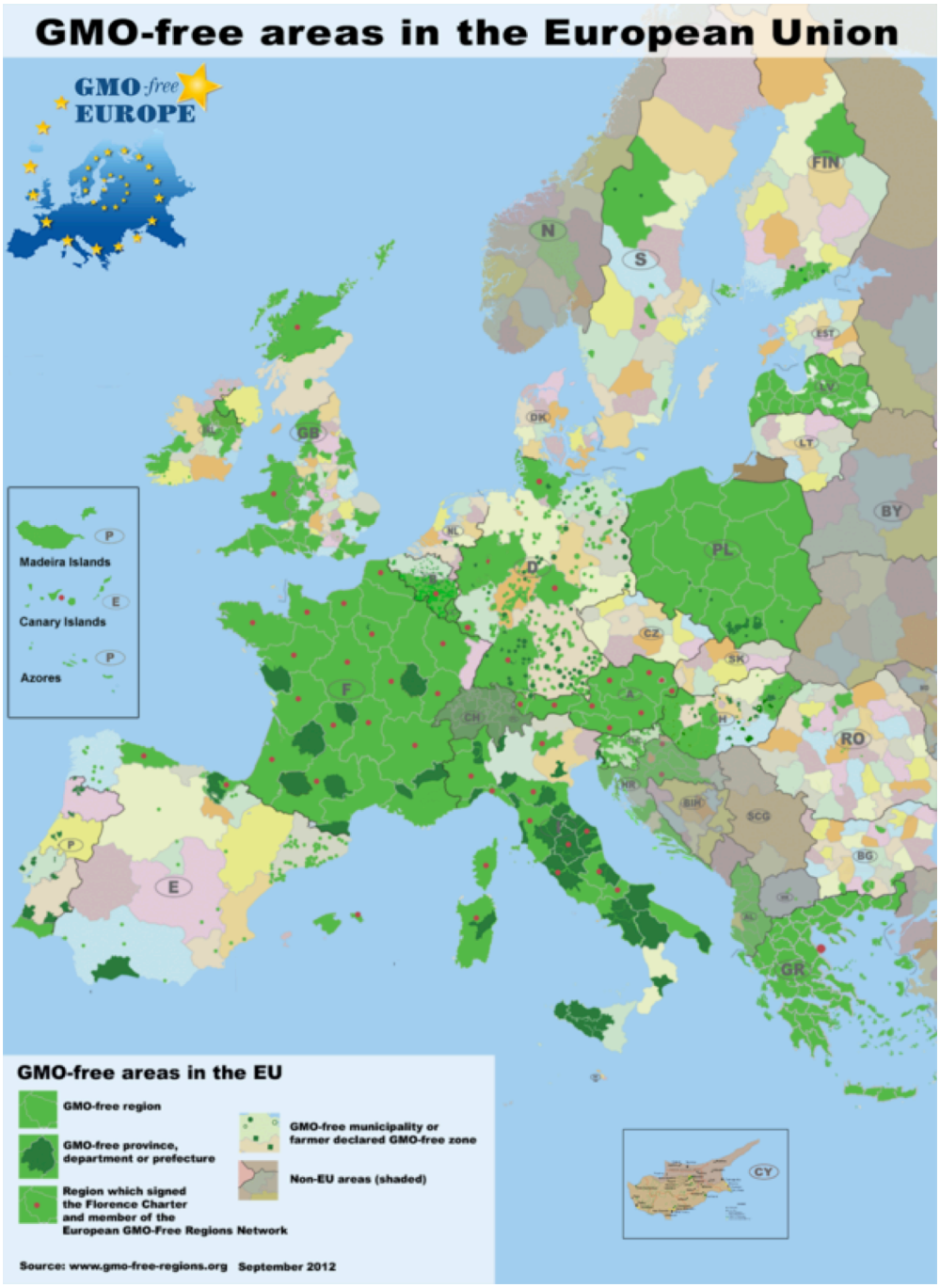

Figure 1. Illustration of European Union national and sub-national areas that regulate the release of GMOs. Source: http://gmo.zs-intern.de/?id=1863.

32. The US National Academy of Sciences noted the large diversity of regulatory solutions when it said that it "is not surprising to find a diversity of regulatory processes for products of genetic engineering because they mirror the broader social, political, legal and cultural differences among countries. Not all issues can be answered by technical assessments alone.

Indeed, conclusions about GE crops often depend on how stakeholders and decision-makers set priorities for and weigh different considerations and values". [14]

Uncertainty and Lack of Scientific Agreement

33. In this part of my statement of evidence I make general comments about uncertainty in assessing the risks of GMOs, the diversity of scientific opinion on the safety of GMOs, difficulty in containing them or difficulty in reversing potential adverse effects.

34. A number of scientific panels and high-level science advisory committees have issued opinions consistent with precaution. These include the Technical Expert Committee of the Supreme Court of India [20], the International Assessment of Agricultural Knowledge, Science and Technology for Development (commonly abbreviated as IAASTD) [21], and the US National Academy of Sciences. [14]

35. The largest and most comprehensive attempt to achieve a consensus on the science of GMO safety and benefits was conducted by the IAASTD. [22] The international report was prepared over a period of five years, involved 400 researchers from all over the world and was adopted by an intergovernmental panel convened by the United Nations. [23] The conclusions were not in line with a simple single scientific perspective on GMOs as the following quotes illustrate.

    a. "The three most discussed issues on biotechnology in the IAASTD [concerned]:

        i. Lingering doubts about the adequacy of efficacy and safety testing, or regulatory frameworks for testing GMOs";

        ii. "Suitability of GMOs for addressing the needs of most farmers while not harming others, at least within some existing IPR [intellectual property rights] and liability frameworks";

        iii. "Ability of modern biotechnology to make significant contributions to the resilience of small and subsistence agricultural systems." [24]

    b. "The pool of evidence of the sustainability and productivity of GMOs in different settings is relatively anecdotal, and the findings from different contexts are variable…allowing proponents and critics to hold entrenched positions about their present and potential value.

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[20] http://timesofindia.indiatimes.com/city/delhi/SC-appointed-Expert-Committee-recommends-moratorium-on-herbicide-tolerant-crops/articleshow/16869664.cms.
[21] **IAASTD**, ed. 2009a. Agriculture at a Crossroads (Washington, D.C.: Island Press).
[22] **Kiers, E.T., Leakey, R.R.B., Izac, A.-M., Heinemann, J.A., Rosenthal, E., Nathan, D., and Jiggins, J.** 2008. Agriculture at a crossroads. Science *320*, 320-321.
[23] **IAASTD**, ed. 2009a. Agriculture at a Crossroads (Washington, D.C.: Island Press).
[24] **IAASTD**. 2009b. Agriculture at a Crossroads: The Synthesis Report of the International Assessment of Agricultural Knowledge, Science and Technology for Development. In International Assessment of Agricultural Knowledge, Science and Technology for Development, B.D. McIntyre, H.R. Herren, J. Wakhungu, and R.T. Watson, eds. (Washington, D.C.: Island Press).

Some regions report increases in some crops…and positive financial returns have been reported for GM cotton in studies including South Africa, Argentina, China, India and Mexico…In contrast, the US and Argentina may have slight yield declines in soybeans, and also for maize in the US…Studies on GMOs have also shown the potential for decreased insecticide use, while others show increasing herbicide use. It is unclear whether detected benefits will extend to most agroecosystems or be sustained." [24]

c. "Other products of modern biotechnology, for example GMOs made from plants that are part of the human food supply but developed for animal feed or to produce pharmaceuticals that would be unsafe as food, might threaten human health…Moreover, the larger the scale of bio/nanotechnology or product distribution, the more challenging containment of harm can become." [24]

d. "Thus, whatever choices are made, the integration of biotechnology [including GM] must be within an enabling environment supported by local research…and education that empower local communities." [24]

e. "No regional long-term environmental and health monitoring programs exist to date in the countries with the most concentrated GM crop production…Hence, long-term data on environmental implications of GM crop production are at best deductive or simply missing and speculative." [24]

36. Release of a living genetically modified organism introduces risks that are different from the release of chemicals. They reproduce, disperse, and evolve, thus pose safety problems considerably different from those posed by non-living products. Once a GMO is released, its multiplication, dispersal, and possible interbreeding with native organisms may make it difficult if not impossible to retrieve or eliminate, or to cost-effectively alter or remediate its effects.

37. Difficulties in containing GMOs and possible irreversibility of any potential adverse effects are matters of concern to scientists, as the following quotes illustrate.

a. "Other potential environmental problems of transgenic crops…may stem, in part, from the fact that the movement of unwanted crop genes into the environment poses more of a management dilemma than unwanted nonliving 'pollutants.' For example, a single molecule of DDT remains a single molecule or degrades. But a single crop allele occurs within an organism that may have the opportunity to multiply itself — and that allele — repeatedly through reproduction. *The fact that unwanted genes can increase their numbers could frustrate attempts at recall or containment*" [emphasis added]. [25]

b. "Here the authors [representing the Ecological Society of America]

[25] An allele is a particular sequence variant of a gene. The quote is from: **Ellstrand, N.C.** 2006. When crop transgenes wander in California, should we worry? Cal Ag *60*, 116-125.

> make the often overlooked point that some releases of GEOs [genetically engineered organisms] may be irreversible, and that *this potential for irreversibility should invoke a precautionary approach*. All too often, the release of GEOs has been compared to the release of an agrichemical. In fact, GEOs and agrichemicals are fundamentally different - chemicals eventually degrade and become diluted as they spread, whereas transgenes have the potential to persist indefinitely and to spread without dilution. Certainly, we should proceed more cautiously when we may not be able to return the environment to its original state" [emphasis added]. [26]

38. There is a lack of information needed to adequately assess some risks, including potential long-term environmental and health and safety effects, contributing to scientific uncertainty in risk assessments of GMOs. [27]

39. It would be too simplistic even to talk in general terms about whether or not "GMOs" are safe. This is because:

    a. they can be made from many different kinds of organisms, *inter alia* viruses, bacteria, plants, fungi and animals, and the ways that they could potentially cause harm to human health or the environment would be different;

    b. they have different intended traits and the ways that they could potentially cause harm to human health or the environment would be different; [28]

    c. they could have different unintended changes;

    d. they are made using methods that are not completely understood and thus may not create fully predictable changes, or changes that are easy to detect.

    e. The tools to make them are becoming more widely available and therefore accessible to more actors, including lay people "tinkering" in their garages. [29] This is unlike the tools used in chemical or radiation mutagenesis and for the creation of transgenic organisms. More kinds of genetically modified organisms and more kinds of

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[26] **Marvier, M.** 2004. The Ecological Society of America voices its concerns. ISB News Rep *May*, 1-3.

[27] **WHO**. 2005. Modern food biotechnology, human health and development: an evidence-based study. (Geneva) Food Safety Department of the World Health Organization http://www.who.int/foodsafety/publications/biotech/biotech_en.pdf.

[28] As the US National Academy of Sciences said: "For instance, a GE trait that alters the nutritional content of a crop would most likely not have the same environmental or economic effects as GE herbicide resistance." **NASEM**. 2016. Genetically Engineered Crops: Experiences and Prospects (Washington, DC: The National Academies Press) .

[29] See for example: "As D.I.Y. Gene Editing Gains Popularity, 'Someone Is Going to Get Hurt' After a virus was created from mail-order DNA, scientists are sounding the alarm about the genetic tinkering carried out in garages and living rooms." https://www.nytimes.com/2018/05/14/science/biohackers-gene-editing-virus.html.

modifications potentially could be released. [30]

40. The methods of creating GMOs, especially emerging methods, are not completely predictable at the biochemical level. For example, researchers attempting to understand the properties of a novel enzyme that degrades plastic, and could be of use in the coastal and marine environment for remediation of plastic pollution, unexpectedly created variants with altered activities. [31] As the researchers involved said: "What actually turned out was we improved the enzyme, which was a bit of a shock…It's great and a real finding." [32]

41. Unpredictability can complicate anticipating and detecting unintended effects. Prominent groups of scientists do not believe that there are adequate *frameworks* for risk assessment of some GM crops. [33] New frameworks of assessment may be needed in such cases.

42. For example, the new technique of genetically engineering crops to express small double-stranded ribonucleic acid (dsRNA) molecules to cause RNA interference (RNAi) in insect pests to kill them [34] is as an example of at type of GMO where expert groups are uncertain that current risk assessment frameworks are adequate.

43. Where no proper framework is in place, data that could lead to agreement on the safety of such products may not be available. When there are entire classes of GMOs for which there is disagreement between scientists that adequate risk assessments can be done, then there can be no general certainty about human health and environmental safety of all GMOs.

    a. This point was articulated by the Scientific Advisory Panel (SAP) convened under the United States Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). [35] The US Environmental Protection Agency "consulted with the SAP on scientific issues that might be unique to RNAi and how they could fit under the existing risk assessment framework." [33] The SAP agreed with the US EPA "regarding inadequacies of the current environmental fate and non-target effects

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[30] For example, the accessibility of both genetic databases is increasing. Coupled with recent revelations that a poxvirus was assembled by purchasing the component DNA fragments through "the mail" and the expectation that portable synthesizing equipment will be more common in the future, even well intentioned molecular biologists, not to mention citizen scientists, could misguidedly create GM organisms with unknown potentials to cause harm. **Sharples, F.E.** 2017. Synthesis of Horsepox from mail-order DNA. Appl Biosaf *22*, 90-91.

[31] **Austin, H.P., Allen, M.D., Donohoe, B.S., Rorrer, N.A., Kearns, F.L., Silveira, R.L., Pollard, B.C., Dominick, G., Duman, R., Omari, K.E.*, et al.*** 2018. Characterization and engineering of a plastic-degrading aromatic polyesterase. Proc Natl Acad Sci USA *in press*..

[32] https://www.theguardian.com/environment/2018/apr/16/scientists-accidentally-create-mutant-enzyme-that-eats- -bottles

[33] **FIFRA**. 2014. RNAi Technology: Program Formulation for Human Health and Ecological Risk Assessment. SAP Minutes No 2014-02 (U. EPA) Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel (SAP) http://wssa.net/wp-content/uploads/RNAi-report_EPA-May-2014.pdf.

[34] **Lundgren, J.G., and Duan, J.J.** 2013. RNAi-based insecticidal crops: potential effects on nontarget species. Biosci *63*, 657-665.

[35] https://www.epa.gov/sap.

testing frameworks for dsRNA PIPs [plant incorporated protectants] and exogenously applied dsRNA products. Uncertainties in the potential modes of action in non-target species, potential for chronic and sublethal effects, and potential unintended consequences in the various life stages of non-target organisms *are sufficient justification to question whether the current Agency framework for ecological effects testing is applicable to dsRNA PIPs*" [emphasis added]. [33]

b. The US National Academy of Sciences issued a similar finding. It said: "More research is required to address the sustainability of, and off-target effects arising from, RNAi approaches." [14]

44. Entrenched positions are held by people on the topic of GMOs, including scientists. From the trenches, benefits or harms can be overstated and unequivocal, uncertainty understated, and contrary views dismissed. *Nature* magazine concluded along similar lines, saying: "Tidy stories, in favour of or against GM crops, will always miss the bigger picture, which is nuanced, equivocal and undeniably messy." [36]

45. Tidy stories about consensus have become normal in the debate on GMOs. While normal, they are not nuanced and they imply a simplicity that is not true to the complexity of views held by the scientific community. For example:

a. The statement by the board of directors of the American Association for the Advancement of Science (AAAS) affirming the safety of GM crops was openly challenged by some members who said that the statement "cannot be assumed to represent the view of AAAS members as a whole." [37]

b. The British Medical Association said: "A great deal of research, of varying quality, has been conducted since 1999 in the arena of genetic modification of food. However, many unanswered questions remain, particularly with regard to the potential long-term impact of GM foods on human health and on the environment. The few robust studies that have looked for health effects have been short-term and specific. There is a lack of evidence-based research with regard to medium and long-term effects on health and the environment. In our view, the *potential* for GM foods to cause harmful health effects is very small and many of the concerns expressed apply with equal vigour to conventionally derived foods. However, safety concerns cannot, as yet, be dismissed completely on the basis of information currently available." [38]

c. The World Health Organisation summed it thusly: "At present, *no*

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[36] **Gilbert, N.** 2013. Case studies: a hard look at GM crops. Nature *497*, 24-26.

[37] **Hilbeck, A., Binimelis, R., DeFrage, N., Steinbrecher, R., Szekacs, A., Wickson, F., Antoniou, M., Berano, P.L., Clark, E., Hansen, M., *et al.*** 2015. No scientific consensus on GMO safety. Env Sci Eur *27*, 4.

[38] **BMA**. 2004. Genetically modified foods and health: a second interim statement. British Medical Association Board of Science and Education http://bit.ly/19QAHSI.

conclusive evidence on environmental advantages or costs can be generalized from the use of GM crops. Consequences may vary significantly between different GM traits, crop types and *different local conditions* including ecological and agro-ecological characteristics" [emphasis added]. [39]

d. *Nature* magazine, regarded as the international voice of science, said that: "In the pitched debate over genetically modified (GM) foods and crops, it can be hard to see where scientific evidence ends and dogma and speculation begin…Researchers, farmers, activists and GM seed companies all stridently promote their views, but ***the scientific data are often inconclusive or contradictory***" [emphasis added]. [40]

e. Professor Sheldon Krimsky, the Lenore Stern Professor of Humanities & Social Sciences in the Department of Urban & Environmental Policy & Planning, School of Arts and Sciences at Tufts University and adjunct professor in the Department of Public Health and Community Medicine at the Tufts School of Medicine said that one "cannot read these systematic reviews [of the scientific literature] and conclude that the science on health effects of GMOs has been resolved within the scientific community." [41]

46. I have illustrated here and elsewhere in my evidence that there are a variety of informed scientific opinions about the safety of GMOs that are or may be released into the environment, the reversibility of potential adverse effects, the potential benefits or even the ability to assess risks of some kinds of GMOs. While there are scientists who have expressed opinions one way or another about all sorts of aspects of GMOs currently commercialised and released in other countries, there is no evidence that I can find that suggests that many scientists hold firm opinions about GMOs of the future—that those so far not commercialised are and will be safe as food or in the environment, or that they should be unregulated:

a. The World Health Organisation says that: "Continuous application of safety assessments based on the Codex Alimentarius principles and, where appropriate, adequate post market monitoring, should form the basis for ensuring the safety of GM foods." [42]

b. The US National Academy of Sciences said: "It is not possible to predict with certainty the traits that will and will not make it to market or be diffused through nonmarket mechanisms in the future." It goes on to say that "[f]uture GE crops…could greatly expand the use of agricultural biotechnology in the development of biofuels, forestry

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[39] **WHO**. 2005. Modern food biotechnology, human health and development: an evidence-based study. (Geneva) Food Safety Department of the World Health Organization http://www.who.int/foodsafety/publications/biotech/biotech_en.pdf.

[40] **Gilbert, N.** 2013. Case studies: a hard look at GM crops. Nature *497*, 24-26.

[41] **Krimsky, S.** 2015. An illusory consensus behind GMO health assessment. Sci Tech Human Val *40*, 883-914.

[42] http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/. Access date 20 March 2018.

restoration, and industrial bioprocessing and thus potentially lead to new risk-assessment and risk-management issues." [43]

The Coastal Marine Area

47. The inclusion of the coastal marine area into the GMO provisions of the proposed Regional Plan for Northland is consistent with Article 10e of the Convention on Biological Diversity which says: "Encourage cooperation between its governmental authorities and its private sector in developing methods for sustainable use of biological resources." [7]

48. Presently, there are no living genetically modified organisms that have been released into coastal marine environments. However, there are many organisms being discussed in the scientific literature. Here I will briefly introduce four such organisms, fish, algae (microalgae), seaweed (macroalgae) and bacteria.

49. GM salmon is intended as a farmed food product. The GM salmon was modified to accelerate growth, allowing the fish to reach market weight much sooner. [44] There is disagreement among scientists about the potential ecological harms that could arise from release of these fish, or any species of fish with the same altered trait. However, the conditions imposed upon regulators mitigate the risk by preventing release, rather than resolving the issue of whether or not the fish could cause ecological harm. [45] The proposed GMO provisions are consistent with other risk mitigation strategies to prevent ecological harm by controlling release.

50. GM algae is intended as a cultivated biofuel. [14] Algae have a high biomass productivity, and they accumulate compounds that make them interchangeable with existing fuels. GM algae are being developed and tested for this purpose. [46] Algae are also a food for oysters, a significant farmed product in Northland. [47] Worldwide, there have been developed yet no regulatory standards for ensuring the safe release of GM algae. [46] The proposed GMO provisions are consistent with other risk mitigation strategies to prevent ecological harm by controlling release.

51. Seaweed has many uses and increasing commercial interest as a farmed crop which suggests that GM seaweed will more likely be developed. Seaweed is an important agricultural product in parts of the world, both as a source of food

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[43] **NASEM**. 2016. Genetically Engineered Crops: Experiences and Prospects (Washington, DC: The National Academies Press) .

[44] **Waltz, E.** 2016. GM salmon declared fit for dinner plates. Nat Biotechnol *34*, 7-9..

[45] **Smith, M.D., Asche, F., Guttormsen, A.G., and Wiener, J.B.** 2010. Genetically modified salmon and full impact assessment. Science *330*, 1052-1053, **Devlin, R.H., Sundstrom, F., and Leggatt, R.A.** 2015. Evolutionary consequences of growth-accelerated genetically engineered fishes. Biosci *65*, 685-700..

[46] **Henley, W.J., Litaker, R.W., Novoveská, L., Duke, C.S., Quemada, H.D., and Savre, R.T.** 2013. Initial risk assessment of genetically modified (GM) microalgae for commodity-scale biofuel cultivation. Algal Res *2*, 66-77..

[47] https://www.aquaculture.org.nz/wp-content/uploads/2011/06/AQUACULTURE_FACTSHEETS_WEB.pdf. **Packer, M.** 2009. Seaweed farming in New Zealand. NZ Aquaculture *May/June*, 6..

and animal feed but also for use in biofuels, fertilizers and cosmetics. Global value of harvested seaweed is US$6 billion. [48] It is a traditional food source for Māori. [49] The potential for macroalgae to reduce demand for fossil fuels is expected to increase interest in wide-scale cultivation. For example, the "UK government envisages between 560 and 4700 km sq of seaweed farms in its long-term energy planning." [50] There are 850 types of seaweed in the New Zealand coastal marine area and three are already commercialised. [47] The techniques of genetic engineering are being applied to macroalgae to improve its characteristics for industrial use. [51] In addition, it is being discussed as a farmed carbon sink to mitigate New Zealand's greenhouse gas emissions. [52] Macroalgae may be genetically modified to improve their use as carbon sinks. [53]

52. A desirable feature of seaweed farming is that it is not reliant on externally applied fertilizers because of excess nutrient flow from terrestrial farming systems. [50] Seaweed farms are a potential mitigation strategy for the environmental harm caused by excess nutrient flows. Excess nutrient flow is a significant concern in New Zealand including Northland, making the use of farmed seaweed a potential industry and therefore too introducing the potential to use GM seaweed.

53. GM bacteria are intended for bioremediation of plastic pollution. [31] Plastic pollution is presently driving large-scale changes in New Zealand, ranging from the banning of microbeads made from plastic to plastic bags in grocery stores. [54] These changes illustrate how motivated the public and government are by the threats to the environment and human health that plastic pollution may cause. As the discussion of other ecological threats, such as exotic predators, has shown, when the public interest in the problem is high the discussion extends to technological solutions for the problem, including the use of GMOs.[55] Already on a global scale, genetically modified bacteria are being discussed as a solution to the problem of plastics pollution which is unlikely to go unnoticed in New Zealand. [56] Worldwide, there have been developed yet no

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[48] https://www.seafoodnewzealand.org.nz/publications/seafood-nz-magazine/article/?tx_ttnews%5Btt_news%5D=267&cHash=048b7e07ae025854333d36408d118d39.
[49] https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10845557.
[50] https://www.theguardian.com/environment/2012/jan/19/gm-microbe-seaweed-biofuels.
[51] **Charrier, B., Rolland, E., Gupta, V., and Reddy, C.R.K.** 2015. Production of genetically and developmentally modified seaweeds: exploiting the potential of artificial selection techniques. Front Pl Sci *6*, 127.
[52] https://www.newstalkzb.co.nz/news/national/kiwi-scientists-study-looking-at-using-seaweed-to-store-carbon-among-world-changing-ideas/.
[53] **Haoyang, C.** 2018. Algae-based carbon sequestration. Earth Environ Sci *120*, 012011.
[54] https://mfe.govt.nz/waste/waste-strategy-and-legislation/plastic-microbeads-ban. https://www.stuff.co.nz/environment/106160806/new-zealand-to-ban-singleuse-plastic-bags.
[55] **Yong, E.** 2017. New Zealand's war on rats could change the world. In The Atlantic. https://www.theatlantic.com/science/archive/2017/11/new-zealand-predator-free-2050-rats-gene-drive-ruh-roh/546011/.
[56] **Editorial**. 2018. The Guardian view on friendly bacteria: an ally against plastic. In The Guardian (UK). https://www.theguardian.com/commentisfree/2018/apr/22/the-guardian-view-on-friendly-bacteria-an-ally-against-plastic.

regulatory standards for ensuring the safe release of GM bacteria. The proposed GMO provisions are consistent with other risk mitigation strategies to prevent ecological harm by controlling release.

Contamination

54. I was asked whether a GMO discharged into water could be considered a "contaminant" in accordance with the definition in the Resource Management Act 1991. Specifically that:

> "contaminant includes any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy, or heat—
> (a)
> when discharged into water, changes or is likely to change the physical, chemical, or biological condition of water…"

55. By definition contaminants include micro-organisms. Because micro-organisms can be made into GMOs are still micro-organisms, then GM micro-organisms could be contaminants. An example from paragraph 53 would be bacteria that might be genetically modified for bioremediation of plastic pollution. Their presence would arguably affect the biological condition of the water especially if they were modified to colonise or survive under conditions or in places that they previously did not. The bacteria might be intended to be used in the coastal marine environment, or might be intended for terrestrial application but may be conducted to coastal marine areas by surface water, wind, or other means.

56. Furthermore, in degrading plastic the GM bacteria potentially could change the chemistry of the water through release of plastic breakdown products. Even if those products were normal constituents of the environment the concentration of them could change water chemistry. This would generically apply to any GMO intended for remediation purposes even if they were introduced to remove a contaminant.

57. Other kinds of GMOs intended for terrestrial applications could also be conducted into the coastal marine area. For example, during flooding or harvesting, GM trees might be carried by rivers into the sea. While presumably at this stage they would not be living modified organisms, depending on whether or not the chemistry of the GMOs was changed, they could alter water chemistry.

58. Any GMO that was created with a trait to grow, reproduce or live under biotic/abiotic conditions that previously precluded that in the relevant CMA could cause changes to at least the biological condition of the water. If as part of the modification it also altered the physical/chemical environment to be able to live in the relevant CMA, then it too could be a contaminant.

59. All these examples are, to the best of my knowledge, hypothetical at this point, but technically plausible.

Gene flow/transfer

60. Gene flow is the movement of genes into a new genome or environment. [57] Invasive species such the algae Undaria and the Asian paddle crab introduced by shipping is an example of gene flow. [58]

61. As described above, gene flow is expected to be a significant source of risk to the environment and that is why containment rather than release has been the strategy to mitigate the risk of existing GMOs relevant to the coastal marine environment. Containment may also fail and that potential should also be considered in a risk assessment. Where the risk of containment failure is considered too high, prohibition of the GMO may be the only effective mitigation strategy. Here I will review the history of containment failures in terrestrial systems, to inform the discussion on the coastal marine environment.

62. Some experts express confidence in identity preservation techniques to control GM plant gene flow where GM plants co-exist with non-GM plants. However, even in countries such as the United States, which has the longest history of commercial release of GM crops, identity preservation systems regularly fail. Examples of where damage has occurred include—

    a. a genetically modified wheat (MON71800) grown only to field trial stage and then discontinued was rediscovered in fields in the US state of Oregon eight years after field trials ended, and again in Montana over ten years from the end of testing. This lead to trade disruptions and arguably reputation damage. [59]

    b. a sister variety called MON71700 that was also never commercialised and grown in only a "limited number of field trials in the Pacific Northwest from 1998 to 2001" [60] was found 15 years later in open fields in the US state of Washington. [61] As a consequence of the recurring detections of unapproved GM wheat from the US, the United States Department of Agriculture "now requires developers to apply for a permit for field trials involving GE wheat beginning with GE wheat planted on or after January 1, 2016." [61]

    c. a form of genetically modified rice that was grown on less than one acre of land for field testing between only 2001 and 2003 was

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[57] **Heinemann, J.A.** 2007. A typology of the effects of (trans)gene flow on the conservation and sustainable use of genetic resources. (Rome) Commission on Genetic Resources for Food and Agriculture, United Nations Food and Agriculture Organisation (UN FAO) Bsp35r1, 94 ftp://ftp.fao.org/ag/cgrfa/bsp/bsp35r1e.pdf.

[58] http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Marine/marine-pests.aspx.

[59] **Gillam, C.** Monsanto settles farmer lawsuits over experimental GMO wheat. http://www.reuters.com/article/usa-monsanto-wheat-idUSL2N0T22O820141112. Access date, 19 April 2016.

[60] https://monsanto.com/company/media/statements/statement-gmo-wheat-plants/. Access date 4 March 2018.

[61] **USDA**. Detection of GE Wheat Volunteer Plants in Washington State. https://www.aphis.usda.gov/aphis/ourfocus/biotechnology/brs-news-and-information/ge+wheat+washington+state. Access date, 4 March 2018

discovered in the US rice supply in 2006.[62] This lead to lawsuits, trade disruptions and arguably reputational damage. Estimated costs to producers were up to US$1.2 billion. [63]

d. an Australian organic farmer sued his neighbour over loss of income because of gene flow from a GM crop. [64] The organic farmer was not awarded damages but the contamination was not disputed.

63. There are many more examples of gene flow. [65] Harm from it has not been studiously calculated according to the United States General Accounting Office. [66] The central conclusion of their recent report was that the United States Department of Agriculture has failed in its duties to measure the costs of admixture.

64. Potential harm from gene flow is not limited to that caused by the seed or pollen leading to admixture with non-GM plants through breeding. [67] Even small amounts that may contaminate products during storage could cause trade disruptions. When mixture of this type is detected in food, it can trigger two different outcomes, depending on the concentration. Above a certain threshold, the product may be rejected (e.g. if it exceeds certification standards or has not been approved for use in the receiving country). [68] Below a certain concentration (e.g. 0.9% for labelling in Europe) it may be allowed for use.[69] In both of these cases, there must be a positive identification of the GMO. Unknown GMOs in food are not automatically considered to be safe at

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[62] **Ledford, H.** 2007. Out of bounds. Nature *445*, 132-133.
[63] **Davison, J.** 2010. GM plants: science, politics and EC regulations. Pl Sci *178*, 94–98.
[64] **Gill, M.** GM appeal rests on 'duty of care'. http://www.theland.com.au/news/agriculture/cropping/general-news/gm-appeal-rests-on-duty-of-care/2727340.aspx. Access date, 19 April 2016
[65] **GAO**. 2008. Genetically Engineered Crops. United States Government Accounting Office GAO-09-60 http://www.gao.gov/assets/290/283060.pdf.
[66] **GAO**. 2016. Genetically engineered crops. USDA needs to enhance oversight and better understand impacts of unintended mixing with other crops. United States General Accounting Office GAO-16-241 .
[67] **Heinemann, J.A.** 2007. A typology of the effects of (trans)gene flow on the conservation and sustainable use of genetic resources. (Rome) Commission on Genetic Resources for Food and Agriculture, United Nations Food and Agriculture Organisation (UN FAO) Bsp35r1, 94 ftp://ftp.fao.org/ag/cgrfa/bsp/bsp35r1e.pdf, **Price, B., and Cotter, J.** 2014. The GM Contamination Register: a review of recorded contamination incidents associated with genetically modified organisms (GMOs), 1997–2013. IJAS *1*, 5.
[68] **Price, B., and Cotter, J.** 2014. The GM Contamination Register: a review of recorded contamination incidents associated with genetically modified organisms (GMOs), 1997–2013. IJAS *1*, 5.
[69] **Heinemann, J.A., Sparrow, A.D., and Traavik, T.** 2004. Is confidence in monitoring of GE foods justified? Trends Biotechnol *22*, 331-336.. The US National Academy of Sciences said: "In the case of GE crops, adventitious presence is the unintended and accidental presence of low levels of GE traits in seeds, grains, or foods. Preventing adventitious presence is valuable for societal reasons because farmers want the freedom to decide what crops to grow on the basis of their skills, resources, and market opportunities and for economic reasons because markets are differentiated and organic and nonorganic, non-GE crops command a price premium…Strict private standards create an additional layer of complexity because producers may meet government guidelines for adventitious presence but fail to meet contract requirements set by private entities" **NASEM**. 2016. Genetically Engineered Crops: Experiences and Prospects (Washington, DC: The National Academies Press) .

any concentration. [69]

65. Among the kinds of organisms specific to coastal marine areas that are presently being discussed for genetic modification are algae. For some species of these organisms, gene flow is considered to be the most important risk for creating unintended environmental harm. "The mechanistic and genomic evidence for extensive [horizontal gene transfer] in cyanobacteria calls for extra caution with GM cyanobacteria for mass culture." [46]

Whangarei and Far North District Council Coastal Marine Area GMO Provisions

66. The precautionary approach adopted by the proposed Whangarei and Far North District Council GMO provisions appears to me to be broadly consistent with other internationally recognised frameworks for *decision-making* also informed by assessing and managing the risks of GMOs, such as described by the risk assessment guidance of the Cartagena Protocol on Biosafety. [70] The GMO provisions appear to align with accepted risk assessment and decision-making frameworks, by—

    a. identifying relevant protection goals [71] (e.g. the "the control of any actual or potential effects of the use, development, or protection of land", protection of "people, communities, tangata whenua, social and cultural wellbeing, the environment and the economy", long term reputation for vigilance against accidental or unintentional GMO cultivation; and biological threats to biodiversity or industry).

    b. considering the GMO and the intended receiving environment and intended use (e.g. medicine, field testing and release).

67. In my view, the proposed management Option B in the Whangarei and Far North District Council section 32 analysis for inclusion into the proposed Regional Plan for Northland comprise a reasonable response to the scientific uncertainty about the effects from outdoor use of GMOs.

    a. A precautionary approach to risk assessment and risk management of GMOs is appropriate and consistent with international frameworks including the Cartagena Protocol on Biosafey [72] and Codex Alimentarius. [73]

    b. Moreover, the proposed option 2 objective F.0.2.1 is adaptive.

    c. Pursuant to proposed C.1.8.5, GMO releases in the coastal marine

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[70] **AHTEG**. 2012. Guidance Document on Risk Assessment of Living Modified Organisms. (http://www.cbd.int/doc/meetings/bs/mop-06/official/mop-06-13-add1-en.pdf: UNEP) United Nations Environment Programme Convention for Biodiversity http://www.cbd.int/doc/meetings/bs/mop-06/official/mop-06-13-add1-en.pdf.

[71] http://bch.cbd.int/cpb_art15/training/module2.shtml#Nationalprotectiongoalsandassessmentendpoints. The Convention on Biological Diversity, to which New Zealand is a party, frames the concept of protection goals in Article 7. https://www.cbd.int/convention/articles/default.shtml?a=cbd-07.

[72] **CBD**. Cartagena Protocol on Biosafety. https://bch.cbd.int/protocol. Access date, 19 April 2016.

[73] **Codex**. 2003. Codex Work on Foods Derived from Biotechnology. In CAC/GL 45-2003. http://www.who.int/foodsafety/biotech/codex_taskforce/en/.

area are prohibited. GMO field trials, viable GMO veterinary vaccines are a discretionary activity. Where a decision-maker determines that a field trial or viable GMO veterinary vaccine has an unacceptable level of risk that cannot be adequately mitigated or managed, the outcome of a risk assessment may be to recommend of the rejection of a GMO field trial or GMO veterinary vaccine. Based on this and other matters that may be taken into account for decision-making, the proposed GMO provisions prohibit the outdoor releases of GMOs that are not medical or veterinary applications. In my opinion, this determination is consistent with recognised international standards.

d. I believe that it is possible in theory to conduct safe field trials in some ecosystems of some types of organisms that have been made into GMOs. However, as noted above, most GMOs relevant to the coastal marine area could pose unacceptable risks even at that scale, should containment be breached. Moreover, terrestrial field trials conducted in New Zealand and overseas have also failed to contain trialled GMOs.[74] Given the high level of certainty the community requires that gene flow from GMOs would not affect producers in the region, prohibition of the release of GMOs for the foreseeable future as provided in the proposed provisions recommended in the Whangarei and Far North District Council section 32 analysis is a reasonable approach to mitigate the uncertainty of effectiveness of measures to prevent gene flow.

Conclusion

68. For these reasons, from a scientific perspective, I support the Proposed Northland Regional Plan – GE / GMO provisions for inclusion into the proposed Regional Plan for Northland.

[74] **Ledford, H.** 2007. Out of bounds. Nature *445*, 132-133, **RNZ**. Call to end GE field trials after safety breach. https://www.radionz.co.nz/news/national/832/call-to-end-ge-field-trials-after-safety-breach. Access date, 3 March 2018, **Davison, J.** 2010. GM plants: science, politics and EC regulations. Pl Sci *178*, 94–98, **Gillam, C.** Monsanto settles farmer lawsuits over experimental GMO wheat. http://www.reuters.com/article/usa-monsanto-wheat-idUSL2N0T22O820141112. Access date, 19 April 2016, **GAO**. 2016. Genetically engineered crops. USDA needs to enhance oversight and better understand impacts of unintended mixing with other crops. United States General Accounting Office GAO-16-241 .

Appendix 1: Professor Jack Heinemann's CV

current September 2018

CURRICULUM VITAE

JACK A. HEINEMANN

CURRENT POSITION	Professor
ADDRESS	School of Biological Sciences University of Canterbury, Christchurch, New Zealand
EMAIL ADDRESS	jack.heinemann@canterbury.ac.nz
TELEPHONE/FAX	64 03 364-2500
CITIZENSHIP	U.S.A. and New Zealand

EDUCATION

1985-1989	Ph.D. in Biology/Molecular Biology University of Oregon, Eugene, OR, USA
1980-1985	B.Sc(Honours) in Biochemistry B.Sc(Honours) in Molecular Biology **University of Wisconsin, Madison, WI, USA**

PROFESSIONAL EXPERIENCE

2007-present	Professor, School of Biological Sciences, University of Canterbury
2003-2007	Associate Professor
1994-2002	Senior Lecturer
2001-present	Director, Centre for Integrated Research in Biosafety, University of Canterbury Member, Biomathematics Research Centre (2001) University of Canterbury
2001-2012	Adjunct Professor/Senior Fellow, GenØk-Centre for Biosafety, Tromsø, Norway
1997-2000	Biochemistry Programme Coordinator (managed 5 undergraduate courses, ~ 20 postgraduate (PhD and MSc) students and 10 academic and technical staff)
1992-1994	Staff Fellow, National Institutes of Health, NIAID, Laboratory of Microbial Structure and Function
1989-1992	Intramural Research Training Award Fellow

	NIAID, NIH, Laboratory of Microbial Structure and Function
1985-1989	Graduate student, University of Oregon, Institute of Molecular Biology
1983-1984	Undergraduate Research Assistant, University of Wisconsin-Madison, Department of Biochemistry

INTERESTS AND EXPERTISE

Genetics and molecular biology of prokaryotic and eukaryotic microorganisms; horizontal gene transfer, particularly conjugation; effects of stress, particularly induced by antibiotics; evolution and biosafety risk assessment; eugenics (historical); influence of language on science.

HONORS AND SPECIAL RECOGNITION

2018	Appointed to the Expert Working Group of the Swiss National Academies of Science on the topic of genetic engineering.
2015	Recipient of the inaugural University of Canterbury Teaching Innovation Award
2014	Recipient of the Tertiary Education Union National Excellence Award in the category of Academic Freedom
2012-	Chosen by the (United Nations) Convention on Biological Diversity Secretariat to serve on the Ad Hoc Technical Expert Group (AHTEG) on Risk Assessment and Risk Management
2012	Special guest speaker University of Hohenheim Centre for Tropical Agriculture 30th Anniversary, Germany
	Keynote Speaker Postgrad Research Showcase, Christchurch
2011	Keynote Speaker, ETH Monte Verita Conference: Understanding and managing ecological novelty, Switzerland
2010	Keynote Speaker, Tropentag Conference: World Food System: A contribution from Europe, ETH Zurich, Switzerland
2009-2012	Chosen by the (United Nations) Convention on Biological Diversity Secretariat to serve on the Ad Hoc Technical Expert Group (AHTEG) on Risk Assessment and Risk Management
2008	Chosen by the (World Bank and UN agencies) IAASTD Secretariat as author representative to the intergovernmental meeting on the IAASTD Report
	Keynote Speaker, Feed the World Conference, London, UK
2007	Selected by the IAASTD Advisory Bureau to serve as an author on the Biotechnology theme of the Synthesis Report
2006	Appointed Lead Author in the IAASTD Global Assessment Report (nominated by Norway)
2005-9	UN Roster of Experts (Biosafety Protocol)

Distinguished Lecture in Microbiology, University of Wisconsin-Madison

2004 Speaker in the New Zealand Royal Society's Science for Parliament Series

2002 Recipient, New Zealand Association of Scientists Research Medal (The Association's Research Medal is awarded each year to a single scientist aged under 40 for outstanding research work, principally undertaken in New Zealand during the three preceding years.)

2001 Visiting Professor, Norwegian Institute for Gene Ecology and the University of Tromsø (with Prof. T. Traavik), Tromsø, Norway

Visiting Scholar, The Rockefeller University (with Nobel Laureate Prof. J. Lederberg), New York, USA

1993 Young Investigator Award from the American Society for Microbiology Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC) [one of four awarded in an international competition]

1989-2003 Various recognition: *National Business Review* Achiever of the Week (14 Feb. 2003); featured in Saunders, J. 2003. Multiple Drug Resistant Bacteria. Microbiology Today (http://www.socgenmicrobiol.org.uk/pubs/micro_today/book_reviews/MTNOV03/MTN03_24.cfm); featured in: Delwiche, C.F. 2000. Griffins and Chimeras: Evolution and Horizontal Gene Transfer. BioScience 50, 85-87; featured in: Ankenbauer, R.G. 1997. Reassessing Forty Years of Genetic Doctrine: Retrotransfer and Conjugation. Genetics 145, 543-549; **keynote addresses**, The Norwegian Biotechnology Advisory Board Meeting (Oslo, Norway, 1997) and International Conference on Gene Transfer Mediated by Bacterial Plasmids (Banff, Alberta, Canada, 1990); invited speaker, "Microbial Stress Response" Gordon Conference, 1994. 1989-1992 **Intramural Research Training Award** (National Institutes of Health); 1980-1989 Undergraduate and graduate school awards include: 1984, **Outstanding Senior** (final year) **Student Award** (University of Wisconsin-Madison Alumni Association); 1983, **Mary Shine Peterson Award** (Department of Biochemistry, University of Wisconsin); University of Wisconsin Forensics Team Scholarship; 1981, Phi Eta Sigma, the Freshman's Honor Society, MACE, the Chancellor's Men's Honor Society; 1986-1986 NIH Molecular Biology Predoctoral Traineeship (University of Oregon).

GRANTS Total value since 1995 ~NZ $4 million

2017 UNFAO ($90,000)

2016 Open access fee grant (US$2250)

2015 Brian Mason Trust ($12,072).

2014- Donations to UC Foundation for pesticide project (~$150,000)

2013-2014 Safe Food Institute ($64,000)

2010-2012 Marsden Fund (Primary Investigator) (NZ $620,000)

2009-2012 GE Biosafety Forecast Service (NZ $492,000)

2008 GE Biosafety Forecast Service (NZ $123,000)

2006-07 Constructive Conversations (subcontract FRST) (NZ$35,000)

2005-07 GE Biosafety Forecast Service (NZ $767,000)

University of Canterbury (NZ $30,000)

United Nations Food and Agriculture Organisation (FAO) report on Gene Flow (NZ $50,000)

Erskine Fund Teaching Fellowship (NZ $20,000)

2004 GE Biosafety Forecast Service (NZ $324,000)

2003 GE Biosafety Forecast Service (NZ $31,000)

2002 FRST: Postdoctoral fellowship (to RJ Weld to work in my laboratory for 3 years)

OECD Fellowship (~NZ $40,000 for RJ Weld to work in Norway for 6 months)

Brian Mason Trust: NZ $15,000 for research on GMOs

2001 Miscellaneous: GENØK (US $10,000); Rockefeller University (US $6,000); University of Canterbury (US $3,000); US-New Zealand ISAT Bi-lateral Relations Grant ($3,200)

2000 Marsden Fund (Associate Investigator) (NZ $447,000)

Ministry of Health (NZ $3,000)

1999 Marsden Fund (Primary Investigator) (NZ $528,000)

Joint U. Canterbury/Crop & Food Res. (NZ $171,000)

Ministry of Health (NZ $8,000)

1995-1998 (1998) Lotteries Health Research Grant (NZ $71,350), University of Canterbury Research Award (NZ $45,000); (1997) Christchurch School of Medicine Summer Studentship Award (to sponsor an undergraduate researcher), Don Beaven Trust Travelling Fellowship (NZ $3,000), University of Canterbury Research Award ($20,000); (1996) Lotteries Science Research Grant (NZ $35,000), (1995) University of Canterbury Research Award (NZ $25,000), University of Canterbury Equipment Award (NZ $90,000)

CONSULTATIONS, SYMPOSIA and PROFESSIONAL ACTIVITIES

Spoken at **over 70 international conferences** (~85% at invitation), presented **>10 keynote addresses** and **chaired over a dozen sessions**. Served on the organising committees of 5 international meetings. ***Referee*** on occasion for **Applied and Environmental Microbiology, Bioessays, Biology Letters Review, Current Microbiology, Drug Discovery Today, Environmental Biosafety Research, Environmental Microbiology and Environmental Microbiology Reports, Environmental Monitoring and Assessment, Environmental Pollution, Environmental Science and Technology, Environmental Sciences Europe, FEMS Microbiology, FEMS Microbiology Ecology, Entropy, Food and Chemical Toxicology, Food Chemistry, Future Virology, International Journal of Antimicrobial Agents, Journal of Applied Microbiology, Journal of Bacteriology, Journal of Organic Systems, Microbial Drug Resistance, Microbiological Research, Microbiology, Microbiology Indonesia, Microbiome, Molecular Biology and Evolution, Molecular Ecology**, **Molecular Microbiology, Nature Biotechnology, Nature Genetics, New Zealand Journal of Zoology, PeerJ, Pharmacological Research, Plasmid**, **Proceedings of the National Academies of Science USA (PNAS), RNA Biology**, **RNA Journal**, **Royal Society Proceedings B**, **Science**, **Science of the Total Environment, Scientific Reports, World Journal of Microbiology and Biotechnology**, and ten granting agencies (NSF, USA;

FRST, Marsden, HRC and Lotteries Grants Board, Auckland Medical Research Foundation, New Zealand; MacQuarie, Australia; NERC and Wellcome Trust, UK, Alzheimer's Foundation, Danish National Research Foundation, Denmark, Slovak Research and Development Agency, Slovak Republic, Beef Cattle Research Council, Canada). Chief organiser of the 1999 International Osmoregulation Conference, Christchurch, New Zealand and the 2009 Hazard ID and Risk Assessment of (Trans)gene Flow, Tromsø, Norway. ***Organiser and Instructor*** of two prominent international courses: School of Bioinformatics and Genomics Summer Course in Phylogenomics (2003, Sweden) and International Biosafety Course (2003-continuing, Norway).

2018 Invited speaker, Catchments Otago, Dunedin
Invited speaker, New Zealand Institute of Medical Laboratory Science meeting, Christchurch
Invited Speaker, One Health Aotearoa Symposium, Wellington

2017 Invited speaker, Massey University at Albany
Invited speaker, United Nations Food and Agriculture Organisation *Antimicrobial use and antimicrobial resistance in horticulture* Rome
Invited speaker, European Parliament *Scientific, human health, husbandry, and socio-economic aspects of antibacterial resistance: time to act* Brussels

2016 Invited speaker: New Zealand Institute of Food Science & Technology, Rotorua

2015 Graduating Year Review of Massey University's Bachelor of Natural Sciences
Invited speaker, New Zealand Association of Scientists conference *Going Public: Scientists speaking out on difficult issues* Wellington
Invited speaker, University of Otago Christchurch School of Medicine *Antibiotic resistance by stealth* Christchurch

2014 Invited speaker Lincoln University
Invited speaker, Miriam College, Quezon City, Philippines

2013 Invited speaker, Understanding Biosafety: Regulation of Genetic Engineering and Genetically Modified Organisms in Agriculture, Hyderabad, India
Invited speaker, Safety Issues in Application of Food- and Biological Technologies, Kunming, China
Invited speaker, UC Teaching Week, Christchurch
Professorial promotions referee, University of California Santa Barbara

2012 Master of Ceremonies International Scientific Conference Can GM Crops Meet India's Food Security and Export Markets?, New Delhi
Invited Speaker, Can GM crops meet India's food security and export markets?, Hyderabad, India
Invited Speaker, GMO Risk Assessment, Independent Biosafety Research and Holistic Analysis, Hyderabad, India

Invited Speaker, Meeting of the Parties (MOP6) side event 1: talk titled "AHTEG on risk assessment and risk management Process and Outcome", Hyderabad, India
Invited Speaker, MOP6 side event 2: talk titled "Horizontal Gene Transfer Field Trials", Hyderabad, India
Invited Speaker, Regional and Stakeholder Forum on Genetic Modification, Hastings, New Zealand

2011 Editorial Board of **DNA and Cell Biology** (http://www.liebertpub.com/products/product.aspx?pid=13)

2010 Invited Speaker, Advancing the Understanding of Biosafety Conference, Nagoya, Japan
Invited Speaker, Third World Network Side Event at the 5th Meeting of the Parties of the Cartagena Protocol, Nagoya, Japan

2009 Invited Speaker Food Markets and Society II: National Symposium on Future Food Technologies, Auckland, New Zealand
Invited speaker: Evolution: the experience, Melbourne, Australia

2008 Expert witness to Tasmanian Joint Select Committee on Gene Technology in Primary Industries (nominated by Hon David Llewellyn, Chair)

2006 Invited speaker, International Biosafety Symposium Meeting of the Parties (MOP3) of the Cartegena Protocol on Biosafety, Curitiba, Brazil
Expert reviewer, Denmark Centre of Excellence Programme.

2005 Expert reviewer on New Zealand Environmental Risk Management Authority's policy paper: Horizontal Gene Transfer
Keynote Speaker, UNEP/GEF National Biosafety Framework Initiative, Dominican Republic

2004 Invited speaker, International Biosafety Symposium Meeting of the Parties (MOP1) of the Cartegena Protocol on Biosafety, Kuala Lumpur, Malaysia
Invited speaker, School of Bioinformatics and Genomics Summer Course in Phylogenomics, Göteborg University, Sweden

2004-2005 Executive Committee, United Nations Environment Programme and GENØK Biosafety Capacity Building Partnership

2003 Scientific consultant to the New Zealand Parliamentary Local Government and Environment Select Committee on "Corngate".
Invited Speaker, American Society for Microbiology ICAAC conference.

2002 Speaker: ERMANZ conference on Horizontal Gene Transfer
Microbial Genetics Conference, Bergen, Norway
New Zealand Microbiology Society Meeting

2001 Advisor to New Zealand Minister of Science in the "Horizontal Gene Transfer Round Table Meeting"

2000 Expert panel New Zealand Ministry of Health
New Zealand PGSF Biotechnology Tender Panel
University of Canterbury Representative to the NZ Royal Commission on Genetic Engineering

1999 Expert Panel on Antibiotic Residues for the New Zealand Ministry of Health

1997 Keynote speaker, The Norwegian Biotechnology Advisory Board Meeting, Oslo, Norway

1993 Advisor to the United States Department of Energy, under the auspices of the American Academy of Microbiology, for genetic modification of bacteria

2002-2004 **Editorial Board** of Targets (Elsevier "Trends" series journal); 1999-2004 **Editorial Board** of Drug Discovery Today (Elsevier "Trends" series).

POSTGRADUATE TEACHING (1995-present)

Experience: Primary supervisor of 13 completed MSc theses, 12 BSc (Hons) theses and 7 PhD theses, and associate or co-supervisor for more than 20 BSc (Hons), MSc and PhD students since joining the University of Canterbury (1994). My research laboratory presently has 3 PhD and 1 MSc student and 1 postdoctoral scholar.

Achievements: My research students received 5 of the 6 poster awards in the 1996 Queenstown International Molecular Biology Meeting attended by researchers from all over the world and uniformly represented by New Zealand and Australian universities. Joanne Kingsbury and Tim Cooper, while PhD students in my laboratory, won the first and second prizes, respectively, for best research talks at the 1998 national meeting of the Microbiology and Biochemical Societies of New Zealand. Tim was a postdoctoral scholar at Michigan State University and is now at Auckland University. Joanne is a postdoctoral scholar at Duke University. Tim was subsequently nominated for the American Society of Microbiology Sternberg Thesis Award. Gayle Ferguson, another of my PhD students, won first prize for her talk at the Microbiology Society national meeting in 2001 and was a postdoctoral scholar at Columbia University, New York.

EXTERNAL TEACHING ACTIVITIES

2014 Faculty and textbook developer for Government of Swaziland short professional course on Biosafety (under contract to Third World Network)

2009 Faculty and Coordinator for the Gateways Partners Symposia Course and Conference on (trans)gene Flow, Tromsø, Norway

2005 Faculty and organiser of the Solomon Islands Biosafety Course

2003-2011 Faculty and instructor International Biosafety Course

2003-4 Principal Organiser and Instructor (2003), Göteborg University's Bioinformatics summer graduate course, Sweden

2000-present PhD examiner: 4 x University of Malay; 5 x University of Otago; 3 x Massey; 2 x Lincoln; 1 x Macquarie University; 1 x Dartmouth University; 1 x University of Sydney, 2 x Massey University
MSc. examiner: 1 x Massey University, 3 x Otago University; 1 x Macquarie University
Assessor (MSc proposals): 3 x Auckland University

Teaching experience during NIH (1990-1994), under- and post-graduate years (1980-1989): 1990-1994 Supervisor, NIH Summer Student Program, Rocky Mountain Laboratories, USA (resulting in a research paper in the journal **Genetics** by an undergraduate student in 1996); 1992-2000, University of Montana USA affiliate faculty; Guest lecturer, University of Montana, 1992-1994 "Advanced Topics in Microbiology", (course 595) University of Montana, Department of Biology; Teaching Assistant for Core Biology Lecture and Laboratory, Department of Biology, University of Oregon, Eugene, OR, USA; Presenter, Special Project Course in Bioethics, Department of Botany, University of Wisconsin, Madison, WI, USA.

STAFF LEADERSHIP ROLES

Serving the University of Canterbury on 13 *ad hoc* committees in addition to standing committees (listed below): chair of the Academic Board Working Party on Space Allocation Policy (2016); chair of the College of Science Biosecurity Programme Committee (2004); Science Faculty Working Committee evaluating proposals for establishing a Department of Biochemistry (1995-6); the AUS Workloads Committee (1996); lead workshops at the Canterbury-hosted Education Forum (1999); and served on the AAC Subcommittee on Appeals Procedures (2000). Presentation to New Zealand Academic Quality Agency for UC audit 2014. Since 1995, I have served on 7 and chaired an additional 6 Search Committees (total of 13) for new academics. Participating in the staff mentorship and buddy programme.

2018 Chair, UC Learning and Teaching Committee sub-committee on revision of the UC "Academic Freedom Policy"

2017 Chair, School of Biological Sciences Professorial Progressions Committee
Appointment committee for new position in biochemistry.

2016 Appointment committee for new position in microbiology.

2015-2017 Elected University Academic Representative to the Council of the Tertiary Education Union
Acting Head of School (ad hoc)
Appointed to the Board of the New Zealand Academic Qualifications Authority

2013-16 President, Tertiary Education Union (TEU) Canterbury Branch

2014- Chair, School of Biological Sciences Teaching and Learning Committee
Executive Committee, School of Biological Sciences
College of Science Strategic Academic Advisory Committee

2013- Co-chair Academic Freedom Aotearoa

2013	Acting Chair, Teaching and Learning Committee of the School of Biological Sciences Observer, UC Promotions Round Associate Professor and Professor
2009	UC Academic Audit Working Group on the role of critic and conscience of society
2007-2008	President, Association of University Staff (AUS) Canterbury Branch
2006-2007	Canterbury representative AUS National Council
2006	AUS National Bargaining Team
2005-2006	Academic Representative (elected) on the Canterbury Branch AUS
2005-2006	School of Biological Sciences Research Committee
2002-2003	Chair, University Institutional Biosafety Committee
2001-2003	Departmental Supervisor of Postgraduate Studies
2002	University Teaching and Learning Committee
2000-2001	Department HSNO-Biology Officer and University representative to the HSNO Consultative Group
2002-2004	Department Safety Committee
1996-2005	Chair (2000), University Joint Academic Student Grievance Committee
1998-2001	Plant and Microbial Sciences Workload Committee
1996-1998	Branch Committee of the Association of University Staff (AUS)
1994-1998	Plant and Microbial Sciences Curriculum Committee
1994-1998	Academic Supervisor of the Graduate Seminar Series

PROFESSIONAL ORGANIZATIONS

1989-continuing	American Society for Microbiology
1994-continuing	New Zealand Microbiology Society
1995-2002	New Zealand Molecular Biology Society
1998-continuing	New Zealand Society for Biochemistry and Molecular Biology
2002-2004	New Zealand Association of Scientists
2015-	New Zealand Association of Scientists
2014-	Australian Society for Antimicrobials
2014-	Alliance for the Prudent Use of Antibiotics

SCIENCE and COMMUNITY

2018: Chemistry World (https://www.chemistryworld.com/news/antibiotic-analogue-puts-researchers-on-path-to-ending-herbicide-drought/3008660.article) 15.02.18; Jack Heinemann Interview (by Steven Galbraith, professor of Mathematics Auckland University). New Zealand Skeptics Journal. Water standards 'need tightening' after antibiotic-resistant E coli found in Christchurch's Avon River (https://www.stuff.co.nz/environment/104822894/water-standards-need-tightening-after-antibioticresistant-e-coli-found-in-christchurchs-avon-river) 19.06.18.

2017: Epoch Times (Israel) http://www.epochtimes.co.il/ October 2017; TVNZ One News https://www.tvnz.co.nz/one-news/new-zealand/nz-study-reveals-herbicides-role-in-superbugs-could-

have-global-significance 18.11.17. Radio New Zealand https://www.radionz.co.nz/news/national/344195/weedkiller-chemicals-linked-to-antibiotic-resistance 19.11.17. Morning Report Radio New Zealand 20.11.17. Newsroom https://www.newsroom.co.nz/2017/11/20/62213/scientist-challenges-epa-over-antibiotic-resistance?platform=hootsuite 21.11.17. Farmers Weekly Herbicide risk to resistance linked 4.12.17.

2016: Doubts About the Promised Bounty of Genetically Modified Crops. New York Times (by Pulitzer Prize journalist Danny Hakim) 29.10.2016 http://www.nytimes.com/2016/10/30/business/gmo-promise-falls-short.html?rref=collection/byline/danny-hakim&action=click&contentCollection=undefined&region=stream&module=stream_unit&version=latest&contentPlacement=2&pgtype=collection&_r=0 also appearing inter alia in Seattle Times (USA) and Houston Chronicle (USA); Nobel laureates criticise Greenpeace's GM stance. Radio New Zealand 2.07.16 http://www.radionz.co.nz/news/national/307786/nobel-laureates-criticise-greenpeace's-gm-stance; Where science ends and the GMO debate really begins. Epoch Times 22.08.2016 http://www.theepochtimes.com/n3/2138956-where-science-ends-and-the-gmo-debate-really-begins/

2015: What Do We Really Know About Roundup Weed Killer? National Geographic 23.04.15 http://news.nationalgeographic.com/2015/04/150422-glyphosate-roundup-herbicide-weeds/; Scientists keep quiet on controversial subjects fearing backlash from peers. nzDoctor 15.04.15 http://www.nzdoctor.co.nz/news/2015/april-2015/14/scientists-keep-quiet-on-controversial-subjects-fearing-backlash-from-peers.aspx; Common pesticides linked to antibiotic resistance. Guardian 24.3.15 http://www.theguardian.com/lifeandstyle/2015/mar/24/pesticides-antibiotic-resistance-study; Study links widely used pesticides to antibiotic resistance. Civil Eats 24.3.15 http://civileats.com/2015/03/24/study-links-widely-used-pesticides-to-antibiotic-resistance/; Popular weedkiller tied to antibiotic resistance. Rodale News 24.3.15 http://www.rodalenews.com/roundup-antibiotic-resistance; Herbicides raise resistance to medical antibiotics. Times of India 24.3.15 http://timesofindia.indiatimes.com/life-style/health-fitness/health/Herbicides-raise-resistance-to-medical-antibiotics/articleshow/46676730.cms; Herbicides may hurt antibiotics. Radio New Zealand 25.3.15 http://www.radionz.co.nz/news/national/269603/herbicides-may-hurt-antibiotics; Study Links Widely Used Pesticides to Antibiotic Resistance. Time Magazine 24.3.15 http://time.com/3756870/pesticides-antibiotic-resistance/?xid=tcoshare; Est-ce que le glyphosate favorise la résistance aux antibiotiques? Amis del Latterre. 24.3.15 http://www.amisdelaterre.org/Nouvel-article,1878.html;

2014: Degrees of usefulness. New Zealand Herald 12.4.14 http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11236723; How can we help feed the world. Waikato Times 4.11.14; Technologie n'est pas magie. Le Monde 28.10.14.

2013: Lead Opinion: Keep the pause button on GM pressed. The Hindu 7.9.13. Genetically engineered foods: myths and truths. Organic NZ 1.2.13. Scientists at odds over GM fungi. NZ Farmers Weekly 25.3.13. Lax GM rules may bite back- scientists. The Press 25.3.12. New GM technology under fire. New Zealand Farmers Weekly. 27.3.13. Scientist warned agency of GM danger. The Press 28.3.13. Claims of lax food safety regulations for GM molecules. Radio New Zealand Nine to Noon. 28.3.13.

2012: GM crops may not resolve food crisis, scientists say. Times of India. 25.9.12. Scientist warns against genetically modified wheat. TV3 News. 12.9.12 http://www.3news.co.nz/Scientist-warns-against-genetically-modified-wheat/tabid/1160/articleID/269009/Default.aspx; GM crop link to liver failure. New Zealand Herald, 12.9.12; GM crop could cause liver failure: scientist. The West Australian, 11.9.12; Scientists wary of CSIRO GM crop. The Australian, 11.9.12; The worm in Bt brinjal. Business Standard (India), 25.3.12; 'Proper risk assessment a must for adopting safe biotech' Times of India. 6.10.12.

2010-2011: Bt. Brinial: Note by Ministry of Environment and Forests, The Hindu, 10.2.10, Rural Report Radio New Zealand, 9.05.11; AgResearch stalls "damaging" report, Dominion Post, 23.6.11; AgResearch tried to block report, The Press, 23.6.11; Signals of gene transfer risk "not adequately tested", The Press, 23.6.11; AgResearch academic in row over GE report, Southland Times, 23.6.11; Radio New Zealand Checkpoint, 23.6.11. Quoted in The Atlantic http://www.theatlantic.com/health/archive/2011/03/the-battle-for-biodiversity-monsanto-and-farmers-clash/73117/, 28.03.11.

2008: Call for Government to invest more in agricultural research, Radio New Zealand, 16.4.08. Arts to get the chop, The Dominion Post, 30.4.08. Executions and amputations as staff protest job cuts, Westport News, 29.4.08. Restructuring goes ahead, Westport News, 30.4.08. Plans for restructuring go ahead, Gisborne Herald, 30.4.08. Claims that GM foods are needed to avert a food crisis are rubbished, Radio New Zealand, 9.6.08; Claims that GM crops are needed to prevent food shortages are disputed by experts, Radio New Zealand, 9.6.08.

2007: GM Corn, 30 minute interview on RNZ Nine to Noon programme 19.7.07; Discussion as to whether new type of genetically modified corn safe for human consumption, RNZ (Morning Report), 7.2.07; Food safety minister asked to reject new type of genetically modified corn, RNZ (6.00am news), 7.2.07; Minister asked to reject GM animal feed, New Zealand Herald, 7.2.07; Lobby tries to halt feed imports, Marlborough Express, 7.2.07; GM maize fears raised, Bay of Plenty Times, 7.2.07; Food lobbyists: Govt must act fast to stop GE corn, Northern Advocate, 8.2.07; Academic research under pressure, Gulf News, 15.2.07; Review of approval of genetically modified corn for animal feed, RNZ (Checkpoint), 21.2.07

2006: The Press (Christchurch) “Gene claims a rationale for abuse” (15 August, p. A8); ABC Science Online “Food Regulator Criticised over new GM corn” (4 August); Interview National Radio’s Morning Report (6 June on High Lysine Corn); Interview National Radio’s Checkpoint (5 June on Corn Food Safety); The Press (Christchurch) Heinemann, J.A. 5 May 2006 Perspectives article “Alarm bells over GM food approval: part 2. Featured in New Zealand Herald 24.03.06 Company wants stockfeed GE corn approved for people; TVNZ and TV3 interview on Frank Sin’s “gay gene”, 6 and 10 pm news 13.03.06; Christchurch Press interview on Frank Sin’s “gay gene”.

2004-5: Heinemann, J.A., Bungard, R. and Goven, J. Confidence in biotechnology requires greater commitment. 3.3.05. Otago Daily Times p. 11. Featured on Checkpoint (National RadioNZ, 25.05.04); Speaking engagements: March Presentation to the WEA; April Palmerston North branch of the Royal Society; Royal Society Parliament Series; July lecturer in National Science Teachers Conference; September Skeptics Society Annual Conference; Presenter in Natural History New Zealand pilot for Discovery “Dr. Know” series.

2003: Heinemann, J.A. 9 May 2003. Economics of GE models fail to convince. **National Business Review** p. 21. Presentation to University of the Third Age. Heinemann, J.A. 25 August 2003. Food chain in NZ must be protected. **New Zealand Herald** p. A15.

2000-2: Heinemann, J.A. 2002. GE or not to be. **NZ Listener** *185*, 8. Interview (April 2002), Morning Programme National Radio "Canterbury research wins international accolades"; and CTV (same topic). Invited speaker for the New Zealand Association for Impact Assessment (May 2002). Instructor "Marvels and Menaces of Microscopic Life" University of Canterbury Continuing Education Course; "Radioactive" Wellington Student Radio interview on antibiotic resistance; Talk on horizontal gene transfer to Canterbury Botanical Society; Featured in news article by Pockley, P. 2000. New law threatens to undermine genetics in New Zealand. **Nature** *406*, 8; Letter to the Editor of the Christchurch **Press**: “Genetic Engineering”; Interviewed by Paul Holmes (Auckland radio) for NewstalkZB (27 June); Radio New Zealand News interviews (30 June and 20 July); Featured in 4 news articles by the Christchurch **Press** on genetic engineering regulations; Heinemann, J.A. June 2000. Open letter to Helen Clark. **The Best Underground Press – Critical Review** (6), *9*, 2; University of Canterbury student newspaper **CANTA** articles: “Why do students but not academics have to be world-class?” (10 May 2000) and "Teaching is as teachers do” (17 May 2000); Heinemann, J.A. 2000. Research hazards. **New Zealand Education Review** (Sept. 8, 2000, p. 9); Heinemann, J.A. 2000. National security risk. NZ Listener (Jul 7), 7-8; interview on horizontal gene transfer by CHTV (1 Nov.); interview National Programme **Eureka!** (Nov. 26-27, 2000); Heinemann, J.A. 2001. The fate of students within our hands. **New Zealand Education Review** (Jan. 12, 2001, p. 7).

Presentations to Lions, Rotary (x2), WEA, University of the Third Age.

1999: Talk on Genetically Modified Food to the Canterbury WEA; Talk on Genetically Modified Food to the Probus Club; Article to University of Canterbury public relations magazine, **Canterbury Research**, entitled: Are all Genes made of DNA?

1998: Talk on Genetically Modified Food to the WEA Bishopdale Community Centre; Article to community magazine, **City Habitat**, entitled "What is a University?"; Article to community magazine, **City Habitat**, entitled "Why You Don't Want to be my Client".

1997: Interview National Programme, New Zealand Public Radio: "Superbugs"; Article to University of Canterbury public relations magazine, **Canterbury Research**, entitled: "The Life and Times of the Undead"; Debate Plains FM, Christchurch, New Zealand: "Risk and Ethics of Genetic Engineering".

1995: Interview National Programme, New Zealand Public Radio: "Antibiotic Resistance"; Advisor for a nationally ranked high school student science project competition.

TOTAL PROFESSIONAL PUBLICATIONS 133

Peer-Reviewed Publications **(*invited)** Total: 71

Journals (53)

Kurenbach, B., Gibson, P.S., Hill, A.M., Bitzer, A.S., Silby, M.W., Godsoe, W. and Heinemann, J.A. 2017. Herbicide ingredients change *Salmonella enterica* sv. Typhimurium and *Escherichia coli* antibiotic responses. **Microbiology** *163*, 1791-1801.

Coray, D.S., Wheeler, N. Heinemann, J.A. and Gardner, P.P. 2017. Why so narrow: distribution of anti-sense regulated, type I toxin-antitoxin systems compared with type II and type III systems. **RNA Biology** *14*, 275-280.

Coray, D.S., Kurenbach, B. and Heinemann, J.A. 2017. Exploring the parameters of post segregation killing using heterologous expression of secreted toxin barnase and antitoxin barstar in an E. coli case study. **Microbiology** *163,* 122–130.

Kurenbach, B., Marjoshi, D., Amabile-Cuevas, C.F., Ferguson, G.C., Godsoe, W., Gibson, P. and Heinemann, J.A. 2015. Sub-lethal exposure to commercial formulations of the herbicides dicamba, 2,4-D and glyphosate cause changes in antibiotic susceptibility in Escherichia coli and Salmonella enterica serovar Typhimurium. **Mbio** *6,* e00009-00015.

Heinemann, J.A., Agapito-Tenfen, S.Z. and Kurenbach, B. 2015. Response to "A 28-day oral toxicity evaluation of small interfering RNAs and a long double-stranded RNA targeting vacuolar ATPase in mice". **Regulatory Toxicology and Pharmacology** *71,* 599–600. (Quality assured by chief editor.)

Hilbeck, A., Rosa Binimelis, R., Defarge, N., Steinbrecher, R., Székács, A., Wickson, F., Antoniou, M., Bereano, P.L., Clark, E.A., Hansen, M., Novotny, E., Heinemann, J., Meyer, H., Shiva, V. and Wynne, B. 2015. No scientific consensus on GMO safety. **Environmental Sciences Europe** *27*, 4.

Heinemann, J.A., Massaro, M., Coray, D. and Agapito-Tenfen, S.Z. 2014. Reply to comment on 'Sustainability and innovation in staple crop production in the US Midwest'. **International Journal of Agricultural Sustainability** *12*, 387-390. (Quality assured by chief editor.)

Heinemann, J.A., Massaro, M., Coray, D. Agapito-Tenfen, S.Z. and Wen, J.D. 2014. Sustainability and innovation in staple crop production in the US Midwest. **International Journal of Agricultural Sustainability** *12*, 71-88. (Is the top download in the history of the journal at over 44,000 total downloads.)

Hilbeck, A., Lebrecht, T., Vogel, R., Heinemann, J.A. and Binimelis, R. 2013. Farmer's choice of seeds in four EU countries under different levels of GM crop adoption. **Environmental Sciences Europe** *25*, 12.

Heinemann, J.A., Agapito-Tenfen, S.Z. and Carman, J.A. 2013. A comparative assessment of the regulation of GM crops containing dsRNA and suggested improvements to risk assessments. **Environment International** *55,* 43-55. (Within one month of publication, this paper became the top download for the journal, surpassing the downloads of the second place paper published in 2004 and the third place paper published in 2011.)

Bigwood, T., Hudson, A.E., Cooney, J., McIntyre, L., Billington, C., Heinemann, J.A. and Wall, F. 2012. Inhibition of Listeria monocytogenes by Enterococcus mundtii isolated from soil. **Food Microbiology** *32*, 354-360.

Rankin, D.J., Turner, L.A., Heinemann, J.A. and Brown, S.P. 2012. The coevolution of toxin and antitoxin genes drives the emergence and dynamics of bacterial addiction complexes as well as intragenomic conflict. **Proceedings of the Royal Society London Biological Science Series B** *279,* 3706-3715.

Heinemann, J.A. and El-Kawy, O.A. 2012. Observational science in the environmental risk assessment and management of GMOs. **Environment International** *45*, 68-71.

Romero-Suarez, S., Jordan, B. and Heinemann, J.A. 2012. Isolation and characteristics of phages infecting Xanthomonas campestris pv. juglandis, the causal agent of walnut blight disease in New Zealand. **World Journal of Microbiology and Biotechnology** *28*, 1917-1927.

Coray, D.S., Heinemann, J.A., Tyrer, P.C. and Keenan, J.I. 2012. Human lactoferrin increases Helicobacter pylori internalisation into AGS cells. **World Journal of Microbiology and Biotechnology** *28*, 1871-1880.

Bigot, B., Lee, W.-J., McIntyre, L., Wilson, T., Hudson, J.A., Billington, C. and Heinemann, J.A. 2011. Control of Listeria monocytogenes growth in a ready-to-eat poultry product using a bacteriophage. **Food Microbiology** *28*, 1448-1452.

Heinemann, J.A., Kurenbach, B. and Quist, D. 2011. Molecular profiling – a tool for addressing emerging gaps in the comparative risk assessment of GMOs. **Environment International** *37,* 1285-1293.

Heinemann, J.A., Kurenbach, B. and Bleyendaal, N. 2011. Evaluation of horizontal gene transfer monitoring experiments conducted in New Zealand between 2004-2009. **Journal of Organic Systems** *6,* 3-16.

Lee, W.-J., Billington, C., Hudson, J.A. and Heinemann, J.A. 2011. Isolation and characterisation of phages infecting *Bacillus cereus***. Letters in Applied Microbiology** *52,* 456-464.

Cooper, T.F., Paixão, T. and Heinemann, J.A. 2010. Within-host competition selects for plasmid encoded toxin-antitoxin systems. **Proceedings of the Royal Society London Biological Science Series B** 277, 3149-3155.

Heinemann, J.A. and Kurenbach, B. 2008. Special threats to the agroecosystem from the combination of genetically modified crops and glyphosate. Third World Network Biosafety Briefing, August 2008.

Filutowicz, M., Burgess, R., Gameli, R.L., Heinemann, J.A., Kurenbach, B., Rakowski, S.A. and Shankar, R. 2008. Bacterial conjugation-based antimicrobial agents. **Plasmid** 60, 38-41.

Bigwood, T., Hudson, J.A., Billington, C., Carey-Smith, G.V. and Heinemann, J.A. 2008. Phage inactivation of foodborne pathogens on cooked and raw meat. **Food Microbiology** 25, 400-406. (One of the Science Direct top 25 papers for its publication period and category).

Tsuei, A.C., Carey-Smith, G.V., Hudson, J.A., Billington, C. and Heinemann, J.A. 2007. Prevalence and numbers of coliphages and Campylobacter jejuni bacteriophages in New Zealand foods. **International Journal of Food Microbiology** 116, 121-125.

Silby, M.W., Ferguson, G.C., Billington, C. and Heinemann, J.A. 2007. Localization of the plasmid-encoded proteins TraI and MobA in eukaryotic cells. **Plasmid** 57, 118-130.

Willms, A.R., Roughan, P.D. and Heinemann, J.A. 2006. Static recipient cells as reservoirs of antibiotic resistance during antibiotic therapy. **Theoretical Population Biology** 70, 436-451.

Heinemann, J.A., Rosén, H., Savill, M., Burgos-Caraballo, S. and Toranzos, G.A. 2006. Environment Arrays: A possible approach for predicting changes in water-borne bacterial disease potential. **Environmental Science and Technology** 40, 7150-7156.

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